Understanding Geothermal Heating and Cooling Systems

Rose Dowdy

EnLink Geoenergy Services, Inc.

What is geothermal?

GEO= EARTH

THERMAL = HEAT

- Use of the earth as a heat exchanger
- Can refer to various techniques
- A proven technology – 50 yrs +

Call it what you will…

- Geothermal heat pumps (GHP)
- Geoexchange
- Ground source heat pumps (GSHP)
- Ground coupled heat pumps

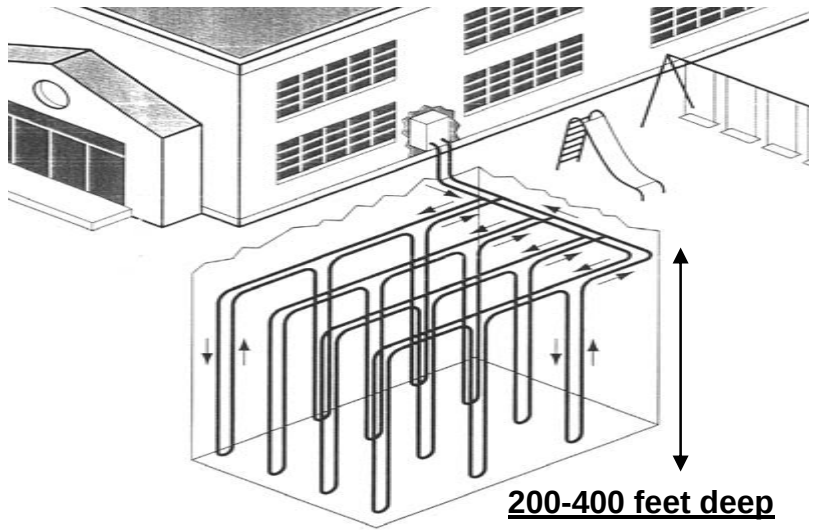
How Does It Work ?

- Heat pumps remove heat from or add heat to the building
- The heat removed or added must be rejected to something:
  - Directly to outside air (like your house system)
  - To water, which in turn rejects heat to atmosphere via a cooling tower
  - To water, then to the earth (geothermal heat pumps)

Main Components of the Geothermal System: Outside

Earth Heat Exchanger (outside)

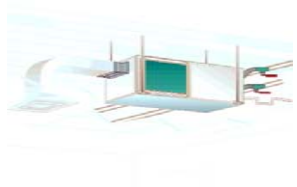
- The Earth Heat Exchanger (EHX) design is a fundamental issue.
- Integrated processes are critical for the efficiency and the reliability of an installation in the long term:
  - Design Engineering Assistance
  - Drilling, Looping, & Grouting
  - Trenching, Headering & Manifolding
  - Testing, Metering, Verification and Acceptance



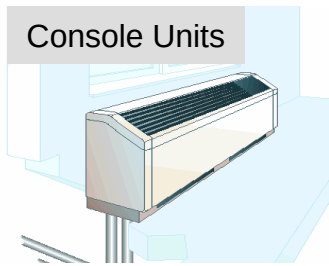
Main Components of the Geothermal System: Inside

Geothermal Heat Pumps (inside)

- A decentralized design: each geothermal heat pump is installed in close proximity to the zone it serves.
- The geothermal heat pump is easy to service and does not require specialized training.



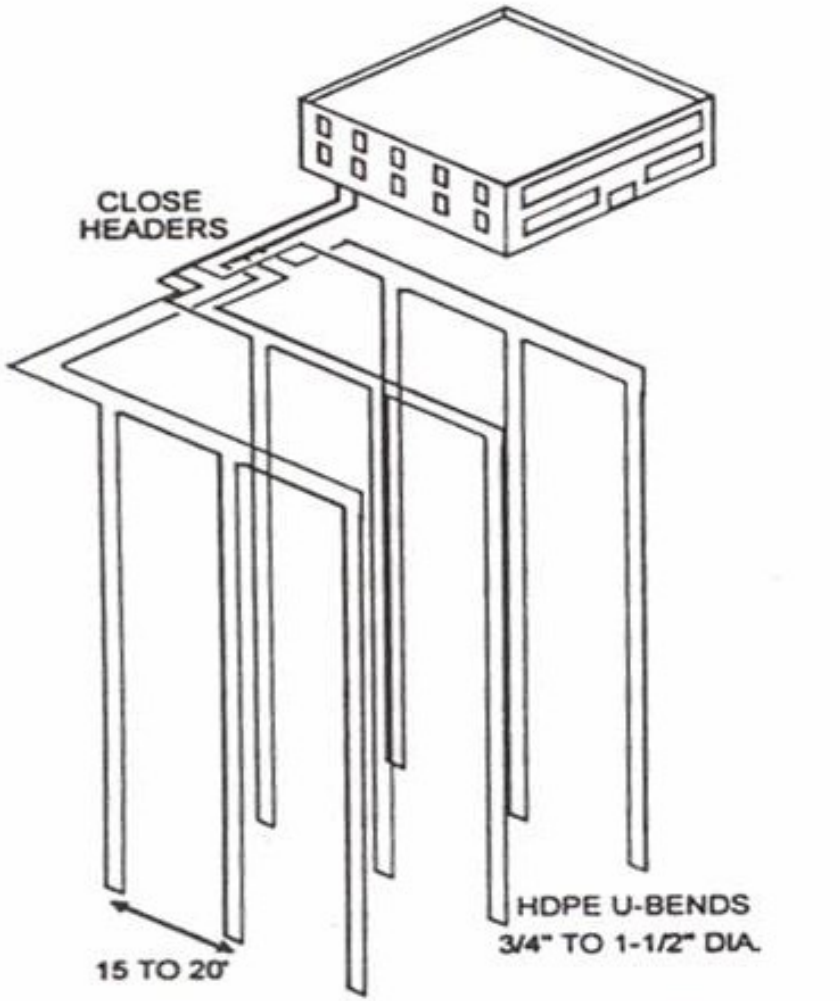
Horizontal Units



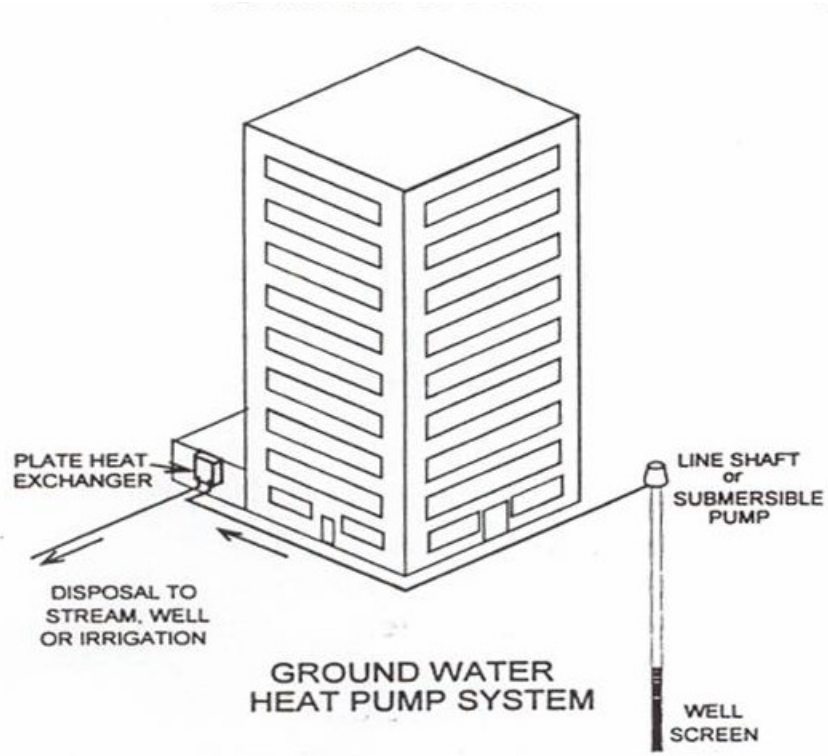
Console Units

Vertical Units

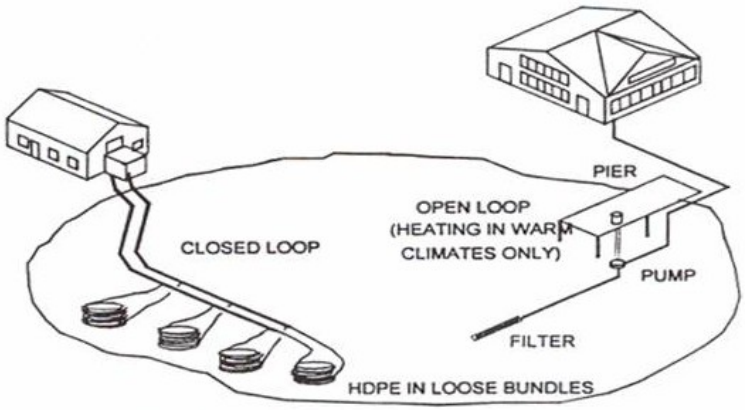
Vertical Stack Units



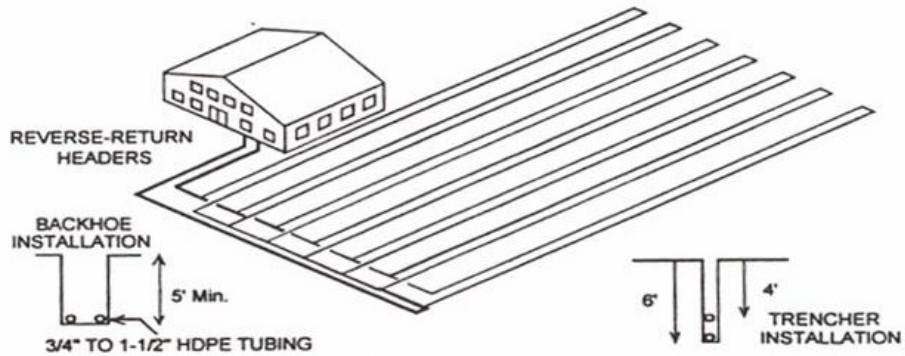
VERTICAL GROUND-COUPLED
HEAT PUMP SYSTEM



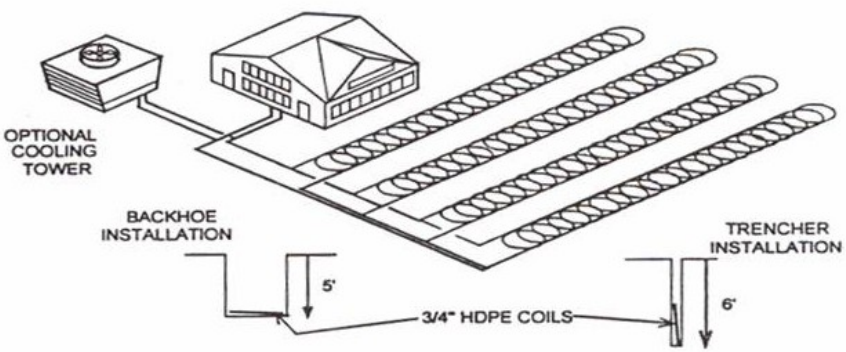
GROUND WATER
HEAT PUMP SYSTEM



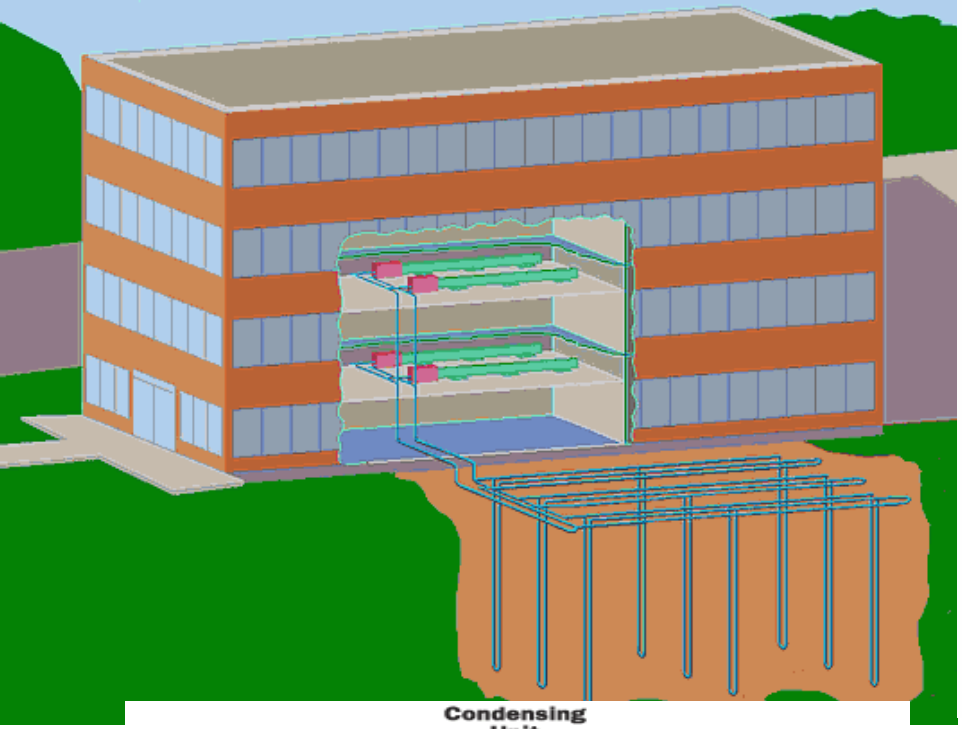
SURFACE WATER HEAT PUMP SYSTEM

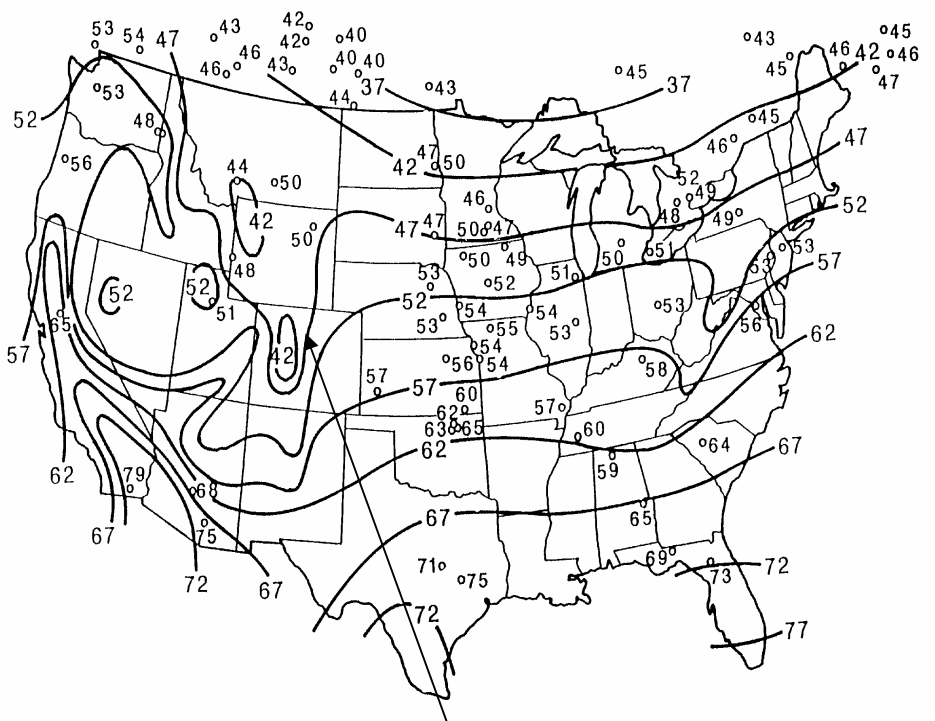


CONVENTIONAL HORIZONTAL GROUND-COUPLED HEAT PUMP SYSTEM

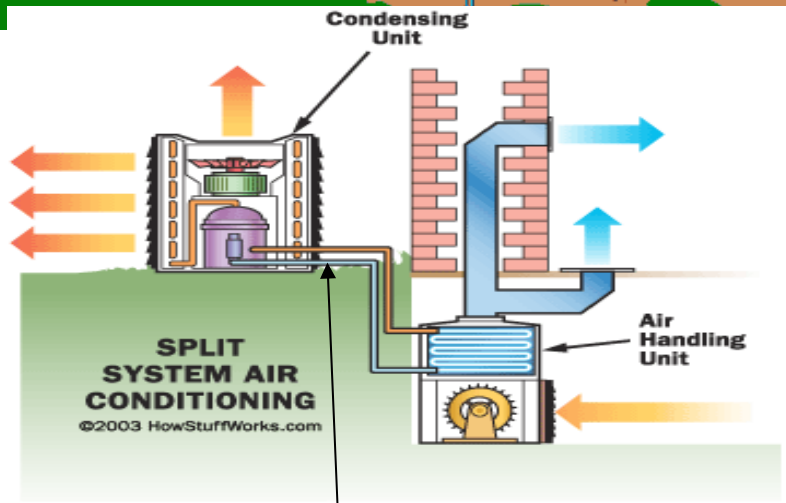


SLINKY COIL GROUND-COUPLED HEAT PUMP SYSTEM





AVERAGE GROUND TEMPERATURES



WHICH IS EASIER TO REJECT HEAT TO ?

105 DEGREE AIR OR 44 DEGREE DIRT

How Does It Affect Architectural Design ?

- Inside the building:
  - Plenum space: little or no difference compared to tower loop heat pumps, chilled water fan coils or vav box type systems
  - Mechanical rooms and shafts: less space than central air handlers
- Outside:
  - Roof: no units on the roof (but can be)
  - No condensing units on the ground
  - No visible loop piping
  - Little affect on finished landscaping. Grading/ paving

Main Benefits of a GHP System (1)

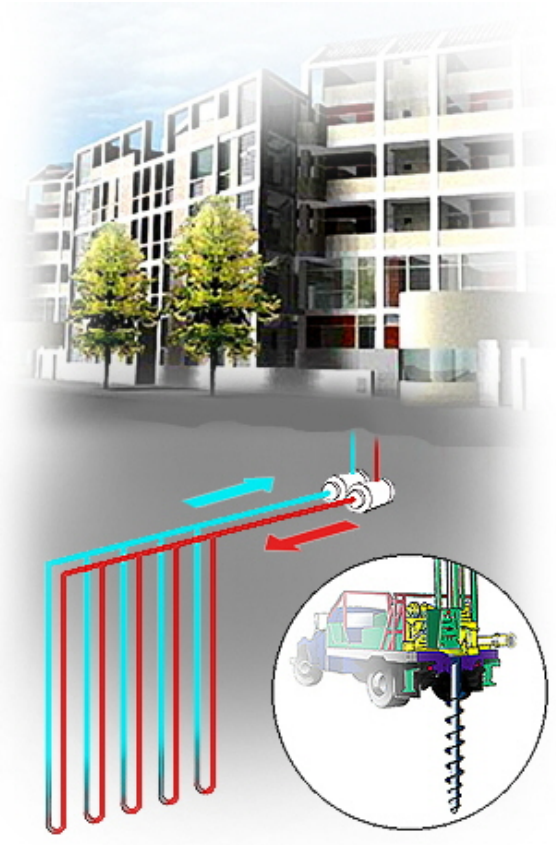
Compared to traditional Systems

- Utility Reduction
  - No water consumption from Cooling Tower
  - No gas consumption for heating
  - GHP dramatically reduces electricity demand (kW) and electricity consumption (KWh) because the system uses the renewable energy stored in the earth.
- Operation and Maintenance Costs Reductions
  - No chiller to chemically treat or maintain
  - No outdoor equipment to clean and maintain
  - No boiler to clean and maintain
  - All exterior components are underground in a sealed system
  - All heat pumps are sealed systems located inside the building

Main Benefits of a GHP System (2)

Compared to traditional Systems

- Eliminate gas boiler
  - No Mechanical Room: Free up additional space
  - Eliminate gas usage, enhance building safety
- Eliminate cooling tower
  - Elimination of unsightly equipment (cooling tower on top of the building roof) and, as a result, reduction in the risk of air-borne diseases
  - Eliminate chemical treatment of water
  - Eliminate water usage
- More comfortable interior environment
  - Individual thermostat control to customize comfor

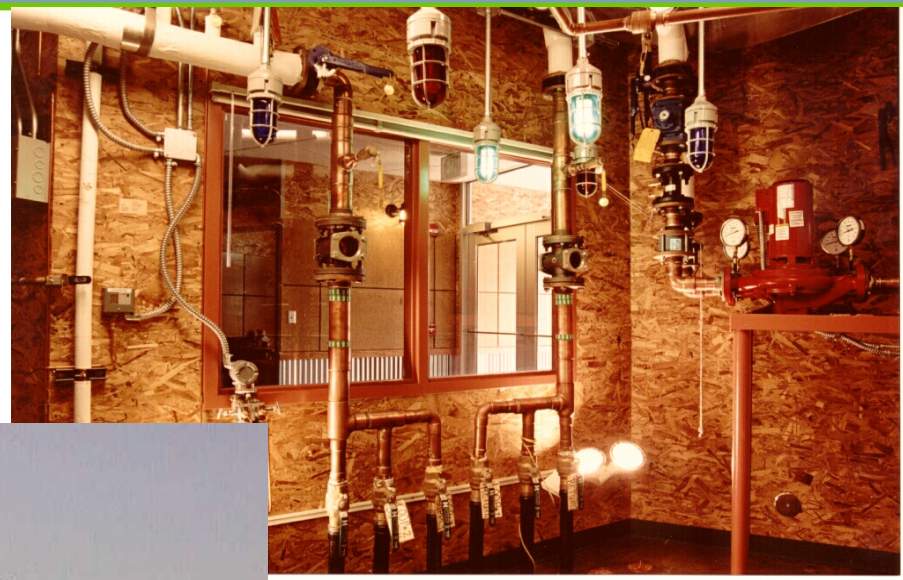


Is Geothermal In Colorado?

- Colorado Springs District #11 – FOTC Building
- Denver Public Schools – Stapleton II k-8
- Lewis Palmer District – Administration
- Pueblo 60 School District – Irving Elementary
- Poudre School District – Operations Ctr
- Canon City School District – High School
- Frenchman School District – Fleming k-12
- Montrose County Health and Human Services Bldg
- Hotchkiss Crawford Historical Museum
- Air Force Academy – Harmon Hall

…….more to follow in 2004

Colorado Projects cont….



Case Study

University Project

University HVAC Retrofit

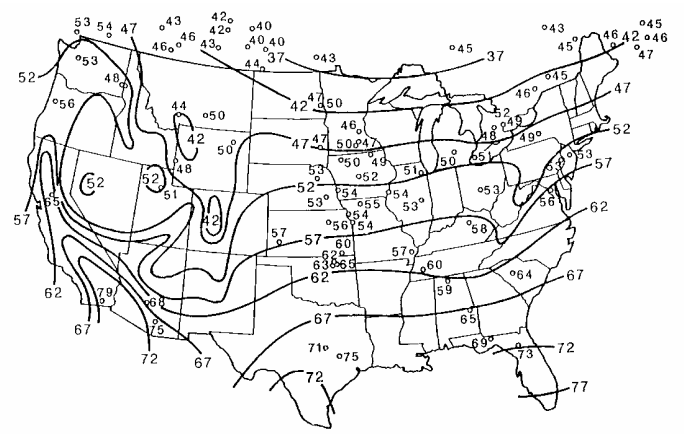
- First 4 buildings (peak cooling 350 tons) of a 20-building retrofit planned over the next 4 years
- 1st Phase contract price - $2.9 million
  - Geothermal 4 buildings
  - Lighting retrofit 20 buildings
- 1st Phase paid through total energy savings
  - Financing capital cost
  - Immediate positive cash flow from project
  - $5.4 million in savings over 20 years
- Construction schedule May 12th – Sept 10th

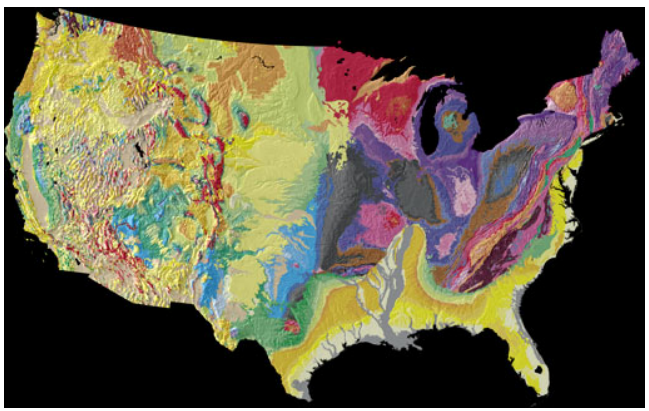
HVAC system before retrofit

Stage 1: Engineering Analysis

Geothermal & Geological Study

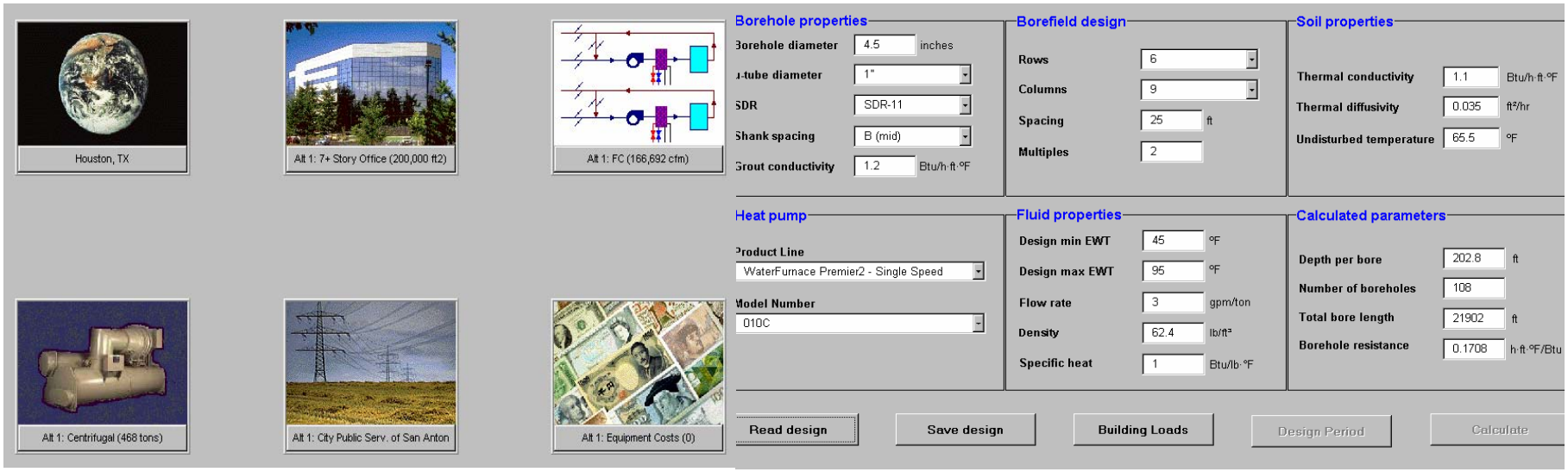
Thermal Conductivity Test





Stage 1: Engineering Analysis

Analysis of the building thermal needs & design of the EHX



Analysis of the building heating and cooling load through Trane Analyzer

Design of the Earth Heat Exchanger (EHX) with EnLink Software (Geodevelopper)

Stage 2: Drilling, Looping & Grouting

Drilling the wells for the Earth Heat Exchanger

Looping & Grouting with EnLink patented Coil Tubing Unit (CTU)

The Drill Rig drills as deep as 400 feet

Stage 2: Trenching & Manifolding

Trenching and Manifolding

Well fields

Connecting the wells with each other

Stage 3: Connection with building

Main connection to the building

Interior piping network connects all the Water Source Heat Pumps to the EHX

Emission Reductions Over System Life

LET'S DO SOMETHING FOR OUR PLANET

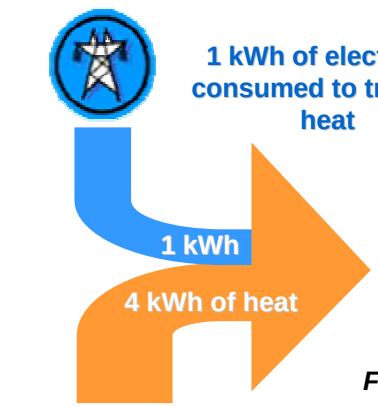
University emission reductions over system life,

Carbon Dioxide (CO_2) in pounds	Sulfur Dioxide (SO_2) in grams	Nitrogen Oxide (NO_X) in grams
971,998	617,039	861,661

U.S. Department of Energy
Energy Efficiency and Renewable Energy

GHP Solution for Sustainable Development

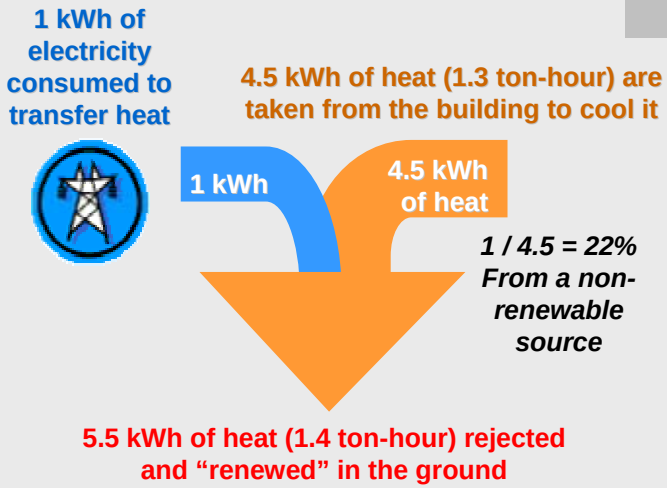
Renewable Energy for Heating In Winter



Energy provided to the building for each increment of 5 kWh required for heating (17 kBtu)

Renewable Energy used for the total comfort need of the building: 80%

Renewable Energy for Cooling In Summer



Energy provided to the building for each increment of 4.5 kWh required for cooling (1.3 ton-hour)

Renewable Energy used for the total comfort need of the building: 78%

Ideal Geothermal Project Criteria

- Building loads that require heating and cooling (space conditioning, water heating, refrigeration, snow melt, etc)
- Parking lot or foot print area available for the earth heat exchanger
- A ground conductivity and ground temperature complimentary to the building load profile
- Utility rate structure beneficial to an all electric facility
- GHP providers in the market to assist the professional team and owner

Industry Organizations and supporters

WWW.GHPC.org

International Ground Source Heat Pump Association

www.igshpa.okstate.edu

EUROPEAN ORGANIZATIONS

- ✓European Heat Pump Association
  www.ehpa.org
- ✓Association Française des Pompes à chaleur
- ✓Federation of Environmental Trade Associations
  www.feta.co.uk
- ✓Sustainable Energy Ireland
  www.sei.ie

http://www.ashrae.org/

Some GHP Users

Commercial Applications

- Conoco
- Philips 66
- Holiday Inn
- Comfort Inn
- Wendy's

Federal Organization

- US Military Bases
- US Post Office
- Oklahoma State Capital
- US Merchant Marine Academy

… Other federal buildings

The Bush Ranch in Crawford, TX.

Schools

- Colorado Springs Dist. 11
- Poudre School District
- Pueblo 60 School District
- Adelphi University

Over 2000 schools nationwide …

Community

- Medina Church of Christ
- Du Pont Medical Center
- Wildlife Center of Virginia
- Kopernik Space Education Center (NY)

Learn more…

GHP Providers may provide assistance:

- Provide owner presentations on the technology
- Provide a feasibility study on the building
  - Include an economic and environmental impact
  - Evaluate comfort and health issues that can be addressed with geothermal
- Develop financing packages
- Partner with local mechanical contractors for a total solution

Thank You!